Mathematical Evaluation

Finding:

Based on the hypergeometric distribution one can be 90 percent confident that at most 39 species could be as sensitive, or more sensitive than the chicken.

The argument that domestic chicken is overly sensitive for inclusion in the range of TRVs necessary to represent the 142 species likely to be found on the site is based on the fact that domestic chicken is the most sensitive species among a total of 7 that have been tested. Effectively the work group is testing the null hypothesis that the Chicken is the most sensitive species among 142 against the alternative that other species may be equally or more sensitive.

To test this hypothesis, one must ask the question: what is the likelihood that the single most sensitive species among the 142 candidate species would be found by chance alone among a sample of 7 species drawn from the collection of 142. The mathematical rules governing this sort of sampling from a finite population without replacement are based on the hypergeometric probability distribution.

The situation is identical to the situation of drawing colored marbles from a jar. In this case consider a jar of 141 white marbles and 1 black marble—the black marble representing the single most sensitive species. The probability that the domestic chicken is the most sensitive species among 142 possible species is equal to the probability of finding that single black marble among 7 marbles selected without replacement from the jar containing 142. This is known as hyper-geometric sampling (Johnson et al. 2005) and it can be shown that the probability of retrieving the single black marble (equivalently the most sensitive species) in just 7 tries (among the 7 tested species) out of a total 142 is just 0.04929.

In simple terms, the probability that the chicken is the most sensitive species among the 142 is less than 5%.

In determining the need to consider the chicken, one should also ask the question: what number of species can I be 90% confident that the chicken would be more sensitive?

This again can be stated based on the hypergeometric probability distribution and can be thought of as looking for a 90 percent confidence limit on the largest number of black marbles that could be in the jar given that none were found among 7 marbles drawn.

Again based on the hypergeometric distribution one can be 90 percent confident that at most 39 species could be as sensitive or more sensitive than the chicken. This suggests that in spite of finding 6 species that are less sensitive than the chicken, the limited number of species that have been tested suggests that the chicken could be as much high as 39th out of 142—only the 73rd percentile of the sensitivity distribution.

Conclusions and Recommendations

Approximately 142 avian species of 41 families have reasonable potential to occur in the Area 1 study area (Table 1, below). The TRV work group determined that acceptable PCB toxicity data (total PCBs, dietary exposure) are available for seven taxa (eastern screech owl, chicken, ring-necked pheasant, mourning dove, American kestrel, mallard, and Japanese quail). It is

recognized that domestic chickens are the most sensitive of tested taxa, but there is substantial uncertainty in extrapolating toxicity data from the “acceptable” data set (i.e., from seven taxa) to over 140 taxa with potential to occur within Area 1.

Given these uncertainties and the objective to provide a reasonable level of protection for untested avian species, the BERA should use High Sensitivity TRVs for evaluating dietary risks to avian receptors from total PCBs. This approach would follow the general approach used by EPA in deriving water quality criteria, where EPA relies on the four most sensitive taxa of available data, with an objective to protect 95 percent of aquatic species most of the time.

Based on mathematical probabilities, it is exceedingly unlikely that the most sensitive species among 142 would be found by chance among the 7 species that have been tested. It would be arbitrary to eliminate the domestic chicken without much stronger statistical evidence that other as yet untested species may be equally or more sensitive to exposure to total PCBs.

References

Johnson, N.L., Kemp, A.W. and S. Kotz. 2005. *Univariate Discrete Distributions.* Third Edition. John Wiley and Sons, New York, NY.